# Using Daub, Bone, and Charcoal Samples to Establish the Chronology of Neolithic Tell Formation, and Establish Settlement Patterns, in the Körös Region, Hungary

Honors Research Thesis

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**Abstract**

The archaeological record indicates that a major transition was taking place from the Late Neolithic to the Early Copper Age periods (6500 years ago) on the Great Hungarian Plain. People abandoned the nucleated tell sites characteristic of the Late Neolithic and started to occupy smaller flat sites. Pottery style, trade patterns, burial customs, and subsistence strategies underwent changes during this period in prehistory. Investigations at two Neolithic tells, Vésztő-Mágor and Szeghalom-Kovácshalom, at Neolithic flat sites around Szeghalom-Kovácshalom, and at several small Early Copper Age sites by the Körös Regional Archaeological Project team provided data that was used to create a model that attempts to explain why societies on the Great Hungarian Plain went through this major social and economic transition. Test excavations of parts of two large Late Neolithic structures in flat sites near the Szeghalom-Kovácshalom tell (SzK 50) were conducted in spring, 2011. These structures and several intrusive features were tentatively assigned to the Late Neolithic period (5000 - 4500 cal. BC) based on Tisza culture ceramic styles. Organic materials, including bone and charcoal, were also collected and radiocarbon dated. These Neolithic structures were built out of mud and other organic materials, such as wood and straw. This building material is called daub. Surface collections and geophysical studies indicate that these structures often burned down at the studied settlement, preserving the daub. The aim of this preliminary study was to radiocarbon date the organic material inside the daub pieces, in order to produce a more accurate chronology of the structures and features at the flat sites. The results showed that the daub did not yield radiocarbon dates that accurately dated to the life of the structures. However, radiocarbon dates from other organic material were used to create a chronology of the structures at both blocks excavated during the 2011 KRAP season.

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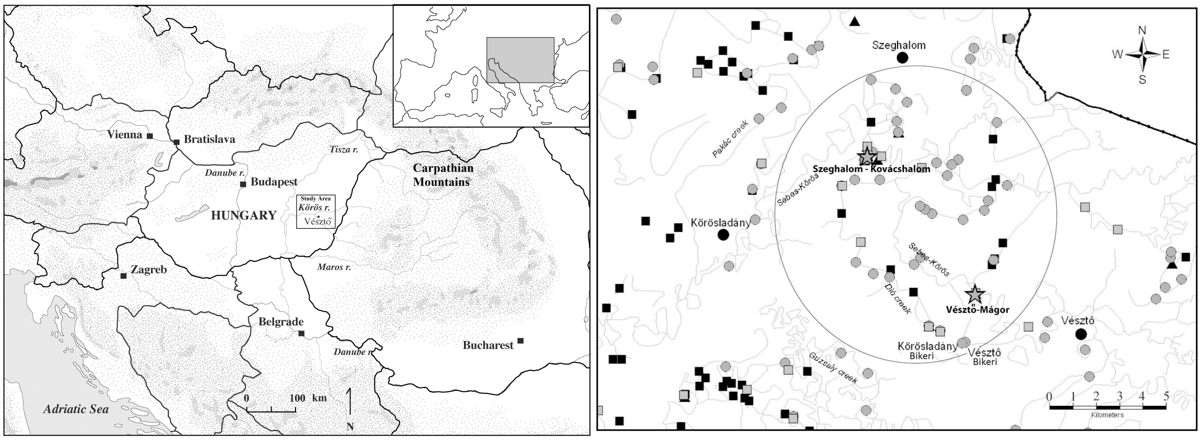
## Chapter 1: Introduction

The goal of this study was to determine if it was possible to use AMS radiocarbon techniques to date the burned daub building materials of Neolithic structures. The radiocarbon samples used in this study were taken from excavated structures and features at two parts of the settlement that surrounds the Szeghalom-Kovácshalom tell (SzK 50) in Békés County, Hungary, occupied during the Middle and Late Neolithic. Fieldwork was conducted at these sites during the spring, 2011 field season of the Körös Regional Archaeological Project (KRAP, see Map 1), directed by Drs. William A. Parkinson (Field Museum, Chicago), Attila Gyucha (Hungarian National Museum), and Richard Yerkes (Ohio State University). One of the goals of the KRAP investigations has been to investigate the physical and cultural processes that led ancient farmers on the Great Hungarian Plain to establish nucleated villages that centered around tells during the Middle and Late Neolithic periods (Fig. 1). Two test excavation units opened in the spring, 2011 season exposed parts of two Late Neolithic structures. Typical Neolithic structures were supported by large wooden posts, with smaller branches woven between the posts. The walls were finished by filling and coating them with clay: a technique called wattle-and-daub construction, in which the daub refers to the clay in the structure. These structures often burned down at Late Neolithic settlements. The daub hardens during the burning process, and is often found during excavations and surface survey.




**Map 1.** Location of the the Körös Regional Archaeological Project (KRAP) in Hungary (left) and archaeological sites in the Sebes-Körös Region (right). **Multi-Component Tell Sites** – grey stars; **Middle Neolithic** (*earlier phase* – AVK) sites - black squares; **Middle Neolithic** (*later phase* – Szakálhát Phase) sites - black triangles; **Late Neolithic** (Tisza Culture) sites – grey squares; **Early Copper Age** (Tiszapolgár Culture) sites – grey circles; Modern towns - black circles. The Sebes-Körös is the middle branch of the Körös River. The Vésztő-Mágor and Szeghalom-Kovácshalom tells, the Vésztő-Bikeri and Körösladány-Bikeri Early Copper Age sites, and nearby sites are within the circle on the right. The Early Copper Age Okány-Futás site is 12 km SE of Vésztő-Bikeri (off the map).

Obtaining radiocarbon dates directly from the building materials would establish an absolute chronology of how structures and settlement organization were changing from the Late Neolithic to the Early Copper Age. The goal for this study was to discern if any datable organic material could be extracted from the daub, which would yield a more precise date for when a structure was occupied, as well as a more accurate chronology for the surrounding parts of the long-lived Szeghalom-Kovácshalom tell. Organic samples, such as charcoal and bone, were also taken from the two test excavation units. Pottery sherds and daub were also collected. The daub, charcoal, and bone samples were sent to Beta Analytic, Inc., where they were dated using an Accelerator Mass Spectrometer (AMS). The $^{14}C$ dates on the bone and charcoal samples fell within the Late Neolithic period (Fig.1). These dates, and the diagnostic Tisza culture ceramics from the test excavation units, suggest that the main period of occupation at the studied settlement locations ringing the Szeghalom-Kovácshalom tell was during the Late Neolithic period. The radiocarbon data gathered from the daub samples did not yield dates that were contemporary with the other radiocarbon samples.

## Chapter 2: Geography of the Great Hungarian Plain

The Szeghalom-Kovácshalom tell is located in the southeastern portion of the Great Hungarian Plain, which is part of the greater Carpathian Basin (Map 1; Parkinson and Gyucha, 2012:2; Sherratt 1997:271-273). Rivers during the Pleistocene period deposited large amounts of alluvial sediments (Sherratt 1997:274). The Carpathian Mountains are on the northern and eastern periphery of the Plain, with the Danube River flowing through the western part of the Plain (Giblin 2011:54) and the Tisza River in the middle of the Plain (Gyucha et al. 2009:103). Between the Tisza and the Danube is a sandy region called the Duna-Tisza-Köze (Sherratt 1997:276), however this region was not heavily occupied during the Late Neolithic and the Early Copper Age (Giblin 2011:57). The soil across the rest of the Great Hungarian Plain is typically chernozem (black soil) that suitable for farming (Sherratt 1997:276). Studies summarized by Parkinson et al. (2010) indicate that the paleoenvironment during the Holocene was stable, and that the middle branch of the Körös River, the Sebes-Körös, near the Szeghalom-Kovácshalom tell changed its course slowly. This, along with the most recent paleohydrological studies at a regional scale (Gyucha et al. 2009), could be used to argue that changing water sources were not an impetus for changes in settlement patterns. The modern landscape of the region is not comparable to the ancient landscape because modern levees constructed in the 19$^{th}$ century have altered the course and flooding patterns of the rivers (Giblin 2011:57; Gyucha et al. 2009:104; Sherratt 1997:275), with flood occurring in the early spring and in the early summer seasons.

The focus of this study is the Körös River system in southeastern Hungary. The three branches of the Körös River (the Sebes, the Fekete, and the Fehér) originate in the Carpathian Mountains and flow together to form the Hármas-Körös. The majority of settlements in the Late Neolithic and the Early Copper Age were founded along small waterways and along the peripheries of flooding areas (Gyucha et al. 2009:112). The Szeghalom-Kovácshalom site was founded along the Sebes-Körös, and could have been subject to the biannual floods common to the region.

## Chapter 3: Cultural History of Middle and Late Neolithic and Early Copper Age Cultures on the Great Hungarian Plain

The transition from the Late Neolithic (5000-4500 cal. BC) to the Early Copper Age (4500-4000 cal. BC) was accompanied by major changes on the Great Hungarian Plain, including shifts in pottery style, trade patterns, burial customs, and subsistence strategies (Parkinson et al. 2010; Sherratt 1997, p. 278-281).

Earlier, the Alföldi Vonaldíszes Kerámia (AVK) group existed during the Middle Neolithic (5500-5000 cal. BC) on the Great Hungarian Plain (Sherratt 1997:279), and might have grown from local cultures that were present during the Early Neolithic (6000-5500 cal. BC). The AVK groups built large, multi-roomed longhouses and manufactured ceramics decorated with linear incisions, and were often painted (Giblin 2011:35). Subsistence during this period focused on domesticated plants and animals (Giblin 2011:35).

From the AVK, several different cultures emerged during the later part of the Middle Neolithic period (Sherratt 1997:280). The Szakálhát culture occupied the lower and middle Tisza Rivers, as well as the Körös River, and made ceramics that were incised and outlined with paint (Sherratt 1997:280). Szakálhát settlements were more concentrated than the earlier Middle Neolithic period AVK sites (Sherratt 1997:306). Tells are artificial mounds that are usually occupied for several centuries and are built up from the remnants of old buildings and other cultural debris (Chapman 1997; Goldberg and Macphail 2006: 225-230; Kalicz and Raczky 1987), and were first established in Hungary toward the end of the Middle Neolithic period (5200-5000 cal. BC) during this Szakálhát phase, after farmers had inhabited the region for nearly a millennium (Fig. 1).

Other contemporary cultures with the Szakálhát were the Esztár, the Tiszadob, and the Bükk. The Esztár culture was geographically widespread, and located north of the Szakálhát along the Nyírség, Szamos and upper Berettyó Rivers (Sherratt 1997:280). Typical Esztár pottery was dark with painted designs (Sherratt 1997:280). The Tiszadob and Bükk were smaller cultures than either Szakálhát or Esztár, and are found in the Sajó valley and the northeast Bükk Mountains, respectively (Sherratt 1997:280). Bükk ceramics, often exported, are finely made, and incised and painted (Sherratt 1997:280, 288). Bükk groups traded stone resources from the mountains along with their fineware (Sherratt 1997:288). The differences in fineware allow archaeologists to distinguish between these Middle Neolithic cultures (Sherratt 1997:280).

The Late Neolithic period ushered in cultural changes that resulted in the development of the Tisza, Csőszhalom, and Herpály cultural complexes on the Great Hungarian Plain (Sherratt 1997:280; Kalicz and Raczky 1987, p. 13-14). The Tisza were found in the southern Great Hungarian Plain and appear to have developed out of the Szakálhát based on the continuity of incised ceramic designs, as well as their continuation and exaggeration of settlement nucleation (Sherratt 1997:280, 307). Small settlements tended to encompass larger sites, resulting in clusters of Late Neolithic settlement systems along water sources (Gyucha et al. 2009:116). The large central sites in the clusters are often tells, and the Tisza people occupied these tells for about a dozen generations (Parkinson and Gyucha 2012). Large longhouses with multiple rooms continued to be constructed during this period. They were made of timber posts, with wattle-and-daub construction, and plastered clay floors (Parkinson 2002:403). These longhouses are thought to have housed extended families (Yerkes et al. 2009). The Csőszhalom and Herpály groups occupied the northern portion of the Plain (Sherratt 1997:280). Magnetometry survey at the tell and the surrounding flat sites at Polgár-Csőszhalom indicate that the Csőszhalom people constructed longhouses, as well as some smaller structures (Giblin 2011:138). Investigations at some of the Herpály tell sites do not indicate any associated settlements around the tells, which is different from the typical Tisza and Csőszhalom settlements (Parkinson & Gyucha 2012:14). The Herpály also built large structures with interior rooms and plastered floors (Parkinson 2006:39). Like the Tisza settlements, the Csőszhalom and Herpály settlements were large, and surrounded by ditches (Sherratt 1997:288). The Tisza, Csőszhalom, and Herpály had an economy based on raising domesticated animals (Sherratt 1997:289), as well as farming grains, hunting, and fishing (Giblin 2011:38).

The transition to the Early Copper Age was characterized by a tendency of homogenization of cultures across the Great Hungarian Plain (Sherratt 1997:281), out of which emerged the Tiszapolgár culture (Bognár-Kutzián 1963, 1972). Tiszapolgár settlements continued to be established along rivers, but had a significantly greater number of small settlements containing a few structures that were occupied for a short amount of time compared to the Late Neolithic settlements (Sherratt 1997:289, 308; Gyucha et al. 2009:116; Parkinson 2002:393). Previous research had suggested that these Early Copper Age structures were smaller than the Neolithic longhouses, and had no interior rooms, and no plastered floors (Parkinson 2002:403). These smaller structures may have housed nuclear families (Sarris et al. 2004; Yerkes et al. 2009). New ceramic stylistic changes, including pedestalling, decorative lugs, new incision styles, and non-painted pottery distinguish the Tiszapolgár from the Late Neolithic cultures (Bognár-Kutzián 1972). Large cemeteries were established during the Early Copper Age despite the dispersed settlement pattern, which differed from the Neolithic tradition of burying the dead within settlements (Bognár-Kutzián 1963; Sherratt 1997:280; Giblin 2011:35). Copper and gold-working, which began in the late Neolithic period, also came into general practice during the Early Copper Age (Sherratt 1997:289). Some researchers suggest that these artifacts indicate that areas around the edge of the Plain became more important because of their proximity to metal sources, as well as access to trade routes that extended over the Carpathian Mountains (Sherratt 1997:281). For subsistence, the Tiszapolgár continued to farm and raise animals at their dispersed sites, but they relied more on domesticated cattle, pigs, sheep, and goats, and hunted less than their Neolithic predecessors (Gyucha et al. 2009; Parkinson et al. 2012; Sherratt 1997:289).

| Absolute Chronology (cal. BC) | Period | Cultures in the Central and Southern Plain | Cultures in the Northern Plain | Cultures in the Eastern Plain and Körös-Berettyó |
|---|---|---|---|---|
| 5400 - 5000 | Middle Neolithic | Alföldi Vonaldíszes Kerámia (Alföld Linear Pottery, or AVK), Szakálhát | Alföldi Vonaldíszes Kerámia (Alföld Linear Pottery, or AVK), Tiszadob, Esztár, Bükk, Szilmeg | Alföldi Vonaldíszes Kerámia (Alföld Linear Pottery, or AVK), Szakálhát, Esztár |
| 5000 - 4500 | Late Neolithic | Tisza | Tisza, Csőszhalom | Tisza, Herpály |
| 4500 - 4000 | Early Copper Age | Tiszapolgár | Tiszapolgár | Tiszapolgár |

**Figure 1**: Cultural chronology from the Middle Neolithic to Early Copper Age, modified from Parkinson et al. (2010).

## Chapter 4: Some Models of Neolithic and Copper Age Culture Change and Settlement Nucleation at Tells

The Late Neolithic cultural complex on which this study focuses is called the Tisza by archaeologists. People belonging to this group occupied tells for about a dozen generations (Parkinson and Gyucha 2012; Yerkes et al. 2009). The structures that were built during this time were large with multiple rooms built to house extended families (Yerkes et al. 2009). This settlement pattern existed for nearly a five hundred years before most of the tells were abandoned at the beginning of the Early Copper Age (about 4,500 cal. BC). At this time, all three Late Neolithic cultural complexes, the Tisza, Herpály, and Csőszhalom, had been replaced by the Tiszapolgár culture. These Early Copper Age settlements were smaller and were occupied for a shorter period of time than the Late Neolithic tells, and were characterized by smaller structures inhabited by nuclear families (Sarris et al. 2004; Yerkes et al. 2009). One of the current research aims of KRAP is to investigate how and why these long-lived tells were formed at the end of the Middle Neolithic. Summaries of these models of settlement change are given by Giblin (2011:89-114), Gyucha et al. (2009:102), and Parkinson et al. (2004:104), and include models based on changes in migration, climate change, conflict, and socioeconomic pressures.

Migration does not seem to explain the pattern of tell abandonment for smaller, shorter-lived flat sites of the Early Copper Age, as the archaeological record shows cultural continuity from the Late Neolithic to the Early Copper Age (Giblin 2011:90). A gradual transitional phase (called Proto-Tiszapolgár) is sometimes present toward the end of Neolithic tell occupation, with similar burial practices, ceramic style, and settlement fortification indicating continuity to the Early Copper Age Tiszapolgár (Giblin 2011:90; Gyucha et al. 2009; Kalicz & Raczky 1987; Parkinson et al., 2004, 2010; Yerkes et al. 2009).

Giblin (2011:92-93) goes on to suggest that it was not climate change that was the impetus for nucleated settlement abandonment during the transition from the Late Neolithic to the Early Copper Age, citing pollen core and faunal data. The pollen core data indicated that no major environmental changes occurred during this time (Giblin 2011:93). The faunal assemblages from Early Copper Age sites were not substantially different in terms of represented species from those at Late Neolithic sites, suggesting that environmental change had not forced people into a subsistence strategy other than farming and raising animals (Giblin 2011:93).

Internal and external conflict may have caused the dispersal of Late Neolithic settlements (Giblin 2011:94). As resources, such as fertile soil and timber, around the highly populated tells become scarce, these populations disperse to utilize areas whose resources are not depleted (Giblin 2011:95). Evidence for increasing conflict can be inferred through more artifacts that can be used as weapons in the Early Copper Age compared to the Late Neolithic, as well as a continuation of fortification of small Early Copper Age settlements (Giblin 2011:104), although no direct evidence for conflict is seen in the archaeological record.

Changes in settlement organization were effected by economies of the Late Neolithic and Early Copper Age populations (Giblin 2011:111). The dispersed, small settlements in the Early Copper Age were better suited for local trade instead of long distance trade that occurred during the Late Neolithic (Giblin 2011:112), and were more advantageous in the "delayed-return farming system" (Giblin 2011:113) than large, heavily populated tells. Although it is unlikely that the changing settlement patterns will ever be attributed to a single cause, it seems as if farming around tells had caused some kind of resource stress, and that a spread out population would have better farming returns (Giblin 2011:111).

## Chapter 5: Radiocarbon Dating Methods and Attempts to Date Daub and Pottery

Radiocarbon dates are invaluable if one wants to understand the absolute chronology of a region. Radiocarbon dating was developed in 1949 by physicist Willard Libby, and has since been applied to organic archaeological materials to determine absolute dates (Sutton and Yohe 2008, p. 177). The element carbon has three naturally occurring isotopes: $^{12}C$, $^{13}C$, and $^{14}C$. The stable isotopes of carbon are $^{12}C$ and $^{13}C$, but $^{14}C$ is a radioactive isotope. This means $^{14}C$ undergoes radiocarbon decay. This radioactive form of carbon is created when cosmic rays bombard $^{14}N$ atoms and eliminate a proton (Libby 1956, p. 98). The $^{14}C$ isotopes oxidize in the upper atmosphere to form carbon dioxide and enter the global carbon cycle.

Plants assimilate $^{14}C$ during the process of photosynthesis, along with the other two stable isotopes of carbon. The isotopes of carbon travel through the food chain, from plants to herbivores to carnivores. When an organism is alive, the amount of $^{14}C$ in the plant is equal to the amount in the atmosphere (Beta Analytic 2011, Radiocarbon Dating: An Introduction). Once the organism dies, this equilibrium is disrupted as the $^{14}C$ begins to decay (Sutton and Yohe 2008, p. 177). Charcoal is used as a source of $^{14}C$ for charred plant remains, and the organic portion of bone (collagen) is used for human and animal remains (Yizhaq et al. 2005). A study by Yizhaq et al. (2005) compared radiocarbon ages obtained from charcoal and bone sources, and found that there was no systematic difference between the two sources (Yizhaq et al. 2005:194).

The principle behind radiocarbon dating is to measure the amount of $^{14}C$ left in archaeological organic materials and to compare this amount to the atmospheric level of $^{14}C$. Since the half-life of $^{14}C$ is a known value ($5568 \pm 30$ years), the age of the material can be calculated given five assumptions that are outlined by Taylor (1987):

1. The amount of $^{14}C$ in the atmosphere and in the oceans has not changed over time.
2. The radioactive isotope integrates evenly in the atmosphere and oceans.
3. The amount of $^{14}C$ in a sample has not been affected by processes other than the natural uptake of the isotope.
4. The conventional half-life of $^{14}C$ is accurate.
5. The levels of $^{14}C$ can be accurately measured.

The one problem in these assumptions is that the levels of $^{14}C$ on Earth have not been constant throughout history, meaning that the measured radiocarbon years garnered from a sample are not equal to calendar years (Taylor and Aitken 1997). To combat this, calibrations curves have been constructed from ancient trees, whose ages are calculated through dendrochronology. The radiocarbon years are calibrated against these established dates, and are then reported as calibrated years before present (cal. BC). The date given is the average age of the sample, given a margin of error (Beta Analytic 2011, Beta Analytic Final Report).

An article written by Bonsall et al. (2002) outlines different methods of dating ceramics, including: a stylistic approach using differences in ceramic shapes, tempering materials and decorative motifs; luminescence dating that measures the amount of radiation still present in the ceramic from its initial firing; radiocarbon dating organic material in the ceramic and/or on the surface; archaeomagnetic intensity analysis that uses the magnetic properties found in the ceramic to identify the time that the earth had the same magnetic field intensity. Radiocarbon dates from ceramics may have several sources of carbon, some of which have the potential to yield a time interval that is younger or older than when the ceramic was fired (Bonsall et al. 2002). Bonsall et al. (2002:53-54) identify two possible scenarios that would result in a radiocarbon date interval that is older than the ceramic: the clay from which the ceramic was made could have old organic inclusions, and soot from the fire may be from older pieces of wood. Contamination from groundwater could bring in younger sources of carbon, causing the date of the ceramic to appear younger (Bonsall et al. 2002:54). To obtain an accurate date of the ceramic, the organic temper used in the ceramic or other organic material from food remains on the surface of the ceramic should be dated (Bonsall et al. 2002:54).

An attempt to radiocarbon date the organic portion of daub was made by Taylor and Berger (1968), but agreement between charcoal and daub samples could not be made. The organic portion of the daub was too small for an accurate radiocarbon date range to be obtained (Taylor and Berger 1968:365). The current study proposes to use AMS radiocarbon dating techniques for dating burned daub samples, which provide a more accurate estimate than the gas proportional method (Beta Analytic 2011, Radiocarbon Dating: An Introduction) employed by Taylor and Berger (1968:364).

The hypothesis to be tested in this thesis is: If any organic material contained in burned daub from a Neolithic structure were carbonized (e.g., wood fragments or plant chaff temper), this charred organic material could be AMS dated and would yield a radiocarbon date, which could be used to estimate the time when the structure was built (and occupied). The absolute date of the structure could be compared with other radiocarbon samples from the Szeghalom-Kovácshalom tell and surrounding settlement parts, to produce a chronological sequence for the establishment of the tell and the occupation of the surrounding parts. If direct dating of daub is possible, then burned daub from the surface above isolated Neolithic structures could be used to estimate the age of those structures before they were excavated.

## Chapter 6: Background on the Tells and Surrounding Sites

The KRAP team led investigations of four Early Copper Age settlements in the Körös region near the Szeghalom-Kovácshalom tell at Vésztő-Mágor, Vésztő-Bikeri, Körösladány-Bikeri, and Okány-Futás (Map 1; Parkinson et al. 2010).

Vésztő-Mágor is a tell site that was founded during the Middle Neolithic Szakálhát phase (Parkinson et al. 2010:170), and was occupied until the Middle Bronze Age in prehistory (Parkinson et al. 2010:169). Magnetometric survey conducted at and around the tell identified anomalies that appeared to be ditches used for fortification, but could not be attributed to a specific phase of occupation because examples of such fortifications can be found at other Late Neolithic, Copper Age, and Bronze Age settlements (Parkinson et al. 2010:169). Two periods of Tiszapolgár occupation were identified on the tell, based on evidence from burials and structures (Parkinson et al. 2010:270).

Another site investigated was a small Early Copper Age village called Okány-Futás (Parkinson et al. 2010:170). The chronology of this site was defined by Tiszapolgár ceramics collected during surface survey, as well as having the magnetic anomalies a few small structures with low artifact densities that suggest a single period of occupation (Parkinson et al. 2010:171). The settlement at Okány-Futás is different from other Early Copper Age sites (e.g. Vésztő-Bikeri and Körösladány-Bikeri) because it seems to lack settlement fortifications (Parkinson et al. 2010:171).

A settlement at Vésztő-Bikeri was also investigated by the KRAP team, and was also described as an Early Copper Age settlement (Parkinson et al. 2010:171). Geophysical survey at Vésztő-Bikeri indicated that there were three ring-shaped anomalies surrounding the site that were identified as a defensive ditch, palisades, and postholes of a platform as defensive fortifications for the village (Parkinson et al. 2010:173). This settlement, unlike Late Neolithic sites and Okány-Futás, appeared to have been occupied for several generations, and the absolute chronology of this village is partly contemporary with Proto-Tiszapolgár layers at the tell site of Berettyóújfalu-Herpály in the adjacent Berettyó Valley (Yerkes et al. 2009; Parkinson et al. 2010:175). Some characteristics of the Vésztő-Bikeri settlement are similar to Late Neolithic and to Early Copper Age settlement organizations (Parkinson et al. 2010:176).

Like the Vésztő-Bikeri settlement, the Körösladány-Bikeri village was dated to two phases of Early Copper Age occupation that had fortifications encircling the site (Parkinson et al. 2010:177; Yerkes et al. 2009). Later periods of occupation from the Late Bronze Age, the Sarmatian, and the Hungarian Conquest were also present, complicating the stratigraphy of the site (Parkinson et al. 2010:176).

The information from these sites can indicate trends in settlement organization that occurred from the Late Neolithic to the Early Copper Age. Settlement fortifications in the form of ditches and palisades continued to be built (Parkinson et al. 2010:180) into the Early Copper Age. The style and size of structures in the Early Copper Age continued to be constructed like the Late Neolithic longhouses with deep wall trenches (Parkinson et al. 2010:180).

## Chapter 7: Radiocarbon Sample Selection and Analysis

The author participated in archaeological survey, remote sensing, computer-assisted mapping, data recording, and artifact analysis during the spring 2010 KRAP field season at the Szeghalom-Kovácshalom tell and associated parts. The results of these surveys revealed potential houses, pits, and other features on and around the tell. During the spring 2011 season, two test excavation units were opened, South Field West Block 1 (S-1, B-1) and East Field Block 1 (E-1, B-1). The test excavation units were placed over magnetic anomalies identified during geophysical surveys by Drs. Apsostolos Sarris and Nikos Papadopoulos that appeared to be burned Neolithic structures (Fig. 2, 3 and 4, see Sarris and Papadopoulos 2010). Two different distribution patterns of structures were identified from this survey. East of the tell and paleochannel, there were dispersed longhouses. Smaller, clustered structures were found to the north, west, and south of the tell and paleochannel.

East Field Block 1 was opened over what the magnetic survey suggested was a large, multi-roomed structure (S6) typical of the Late Neolithic (Fig. 3, also see Sarris and Papadopoulos 2010). Test unit E-1, B-1 was a 2x3 meter block located over the center of the southwest wall of the S6 longhouse structure. South Field West Block 1 (S-1, B-1) was opened over magnetic anomalies that identified a smaller, burned structure, S36 (Fig. 4, also see Sarris and Papadopoulos 2010). Test unit S-1, B-1 was a 2x3 meter block laid out over the western end of the north wall of Structure S36, however a 1x1 meter extension was opened to the east of the original test unit to expose two intrusive burials (Features 3 and 4, see Fig. 4).

Samples of bone, charcoal, burned pottery sherds, and daub were selected from each test excavation unit. Daub samples were selected from excavated contexts that also contained datable organic material so that the dates between the experimental daub samples could be compared with material that is already known to yield accurate dates (Yizhaq et al. 2005). Along with the absolute dates from the organic artifacts, diagnostic sherds were analyzed to establish a general time frame for structures S6 and S36.

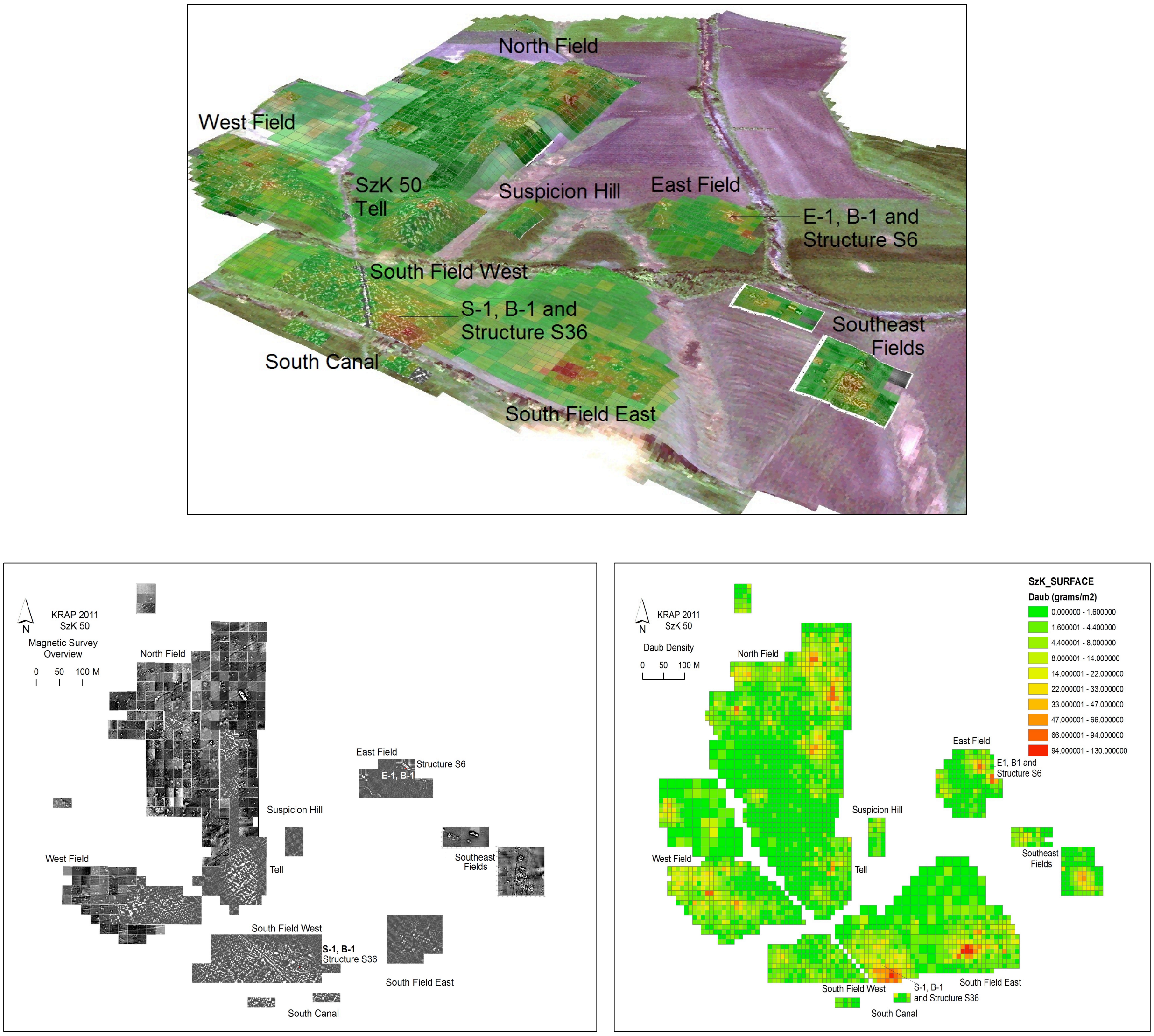



**Figure 2**. Top: The Szeghalom-Kovácshalom tell (SzK 50) and its immediate surrounding in Békés County, Hungary. Locations of test excavation units E-1, B-1 and S-1, B-1 are shown. Note that red and orange squares with high surface density of burned daub are usually located above rectangular magnetic anomalies identified as Neolithic structures. Bottom left: Results of magnetic survey. Bottom right: Burned daub density. The plan and 3D images of topography, magnetic survey results, and daub density were created by Dr. Paul Duffy (University of Toronto).

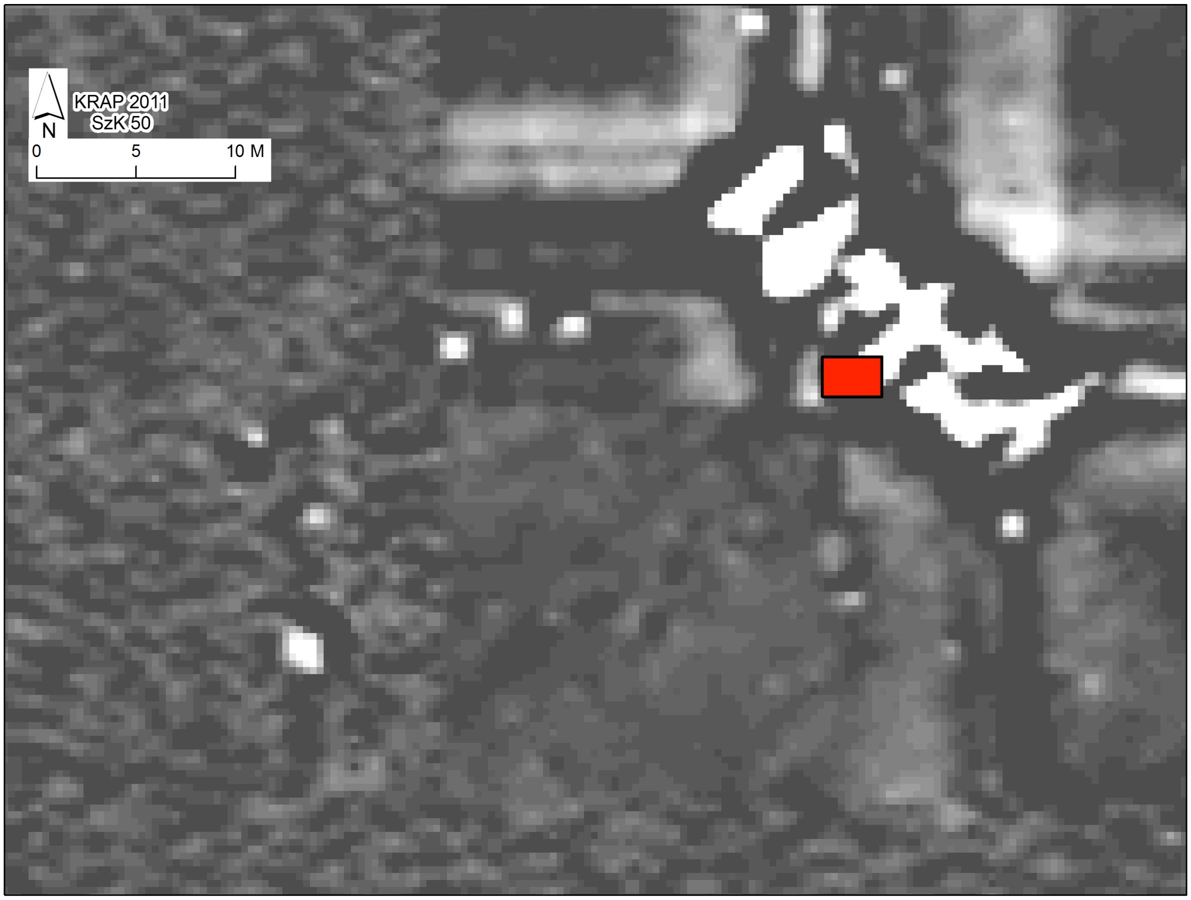



**Figure 3**: Close-up view of rectangular magnetic anomaly identified as structure S6 in East Field. Location of test unit E-1, B-1 is shown in red.

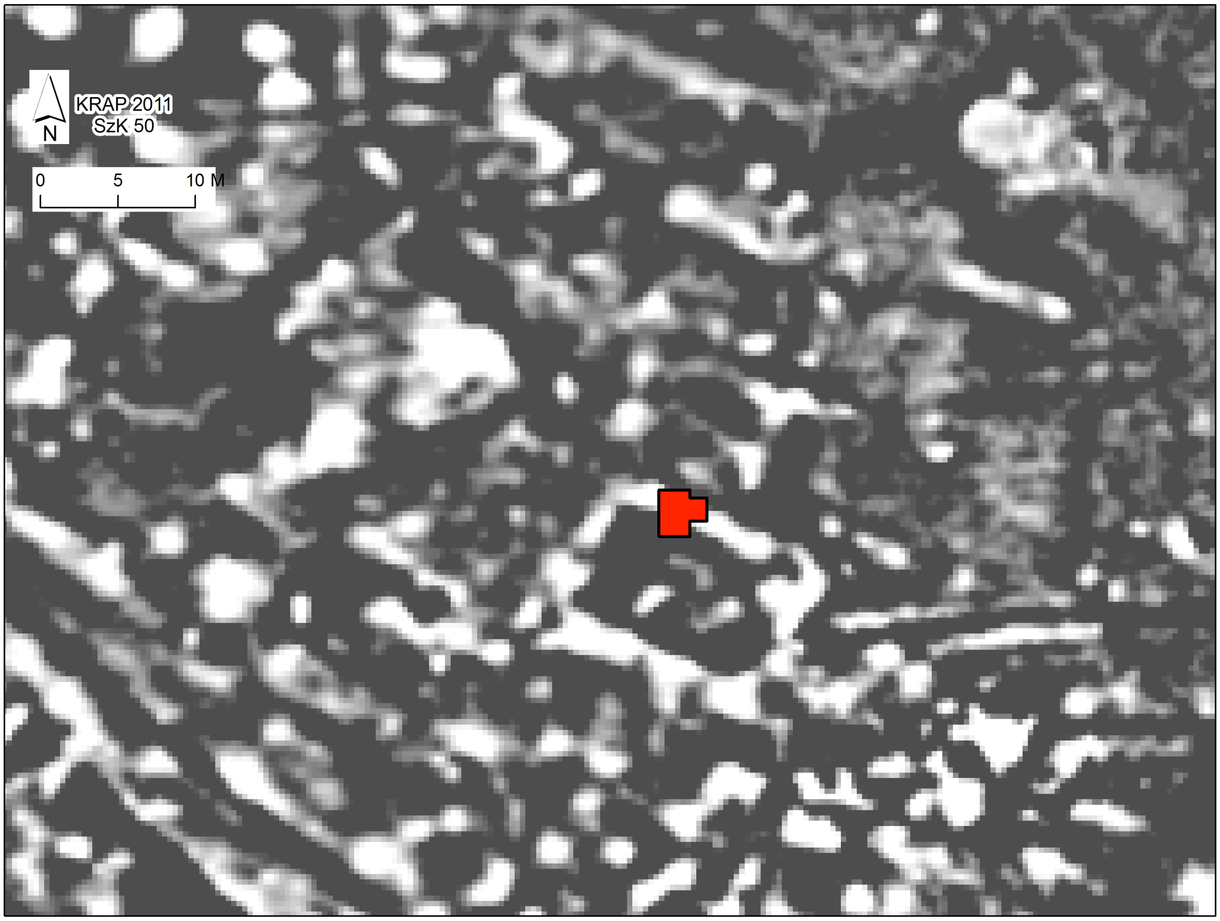



**Figure 4**: Close-up view of rectangular magnetic anomaly identified as structure S36 in South Field West. Location of test unit S-1, B-1 is shown in red.

The radiocarbon sample preparation and analysis were completed by Beta Analytic Inc (http://www.radiocarbon.com). The particular method of sample preparation applied was dependent on the type of sample that was submitted. An Accelerator Mass Spectrometer (AMS) radiocarbon dating method was used for all of the samples discussed in this thesis. AMS dating requires a smaller sample size (as small as 20 mg) and gives a more precise date when compared to traditional radiometric dating (Beta Analytic 2011, Radiocarbon Dating: An Introduction). The sample is burned and turned into graphite, and then is vaporized and run through the mass spectrometer. The different chemical pre-treatment processes for each type of artifact are as follows:

*Bone*: Bone is composed of organic protein and inorganic hydroxyapatite (Beta Analytic 2011, AMS Carbon Dating of Bone Samples), and it is the organic collagen that is used in radiocarbon dating. Bone samples that are burned or too soft do not typically contain a large enough sample of collagen to be dated. If the lab determines that a sufficient amount of collagen is present to proceed, the sample is ground down to a powder and washed in hydrochloric acid (HCl) to remove the inorganic hydroxyapatite. Then the sample is washed again in an alkali solution (for the samples in this study, sodium hydroxide, NaOH was used) to remove any remnants of organic acid.

*Sherds*: There are three ways that Beta Analytic (2011, Radiocarbon Dating Pottery) approach radiocarbon dating of pot sherds: (1) dating charred organic remains on the surface of the sherd (Stott et al. 2003), or (2) dating the organics inside the clay, as well as the other organic molecules from food or liquid that may have been absorbed during storage, or (3) directly dating organic temper found in the sherd (O'Malley et al. 1998; Bonsall et al. 2002). These different sources of $^{14}C$ may result in radiocarbon dates that are conflicting due to contamination, and do not represent the true age of the sherd (Bonsall et al. 2002). Like the bone samples, the sherds are crushed and washed with HCl to remove the inorganic carbonate molecules.

*Charcoal*: The pretreatment procedure used for charcoal samples began with a wash of HCl to remove the carbonates, followed by a wash of NaOH to remove the organic acid. The sample is rinsed for a final time with HCl to neutralize the NaOH. One problem that is possible in radiocarbon dating charcoal is that some wood may have been very old – perhaps the tree had lived for several centuries before wood from it was burned. This would yield a date that is older than the actual time that the wood artifact was burned.

*Daub*: In this study, the daub samples were treated as organic sediment. Each sample was crushed and ran through a sieve to remove any large pieces of roots or macrofossils that would distort the age estimation. The sample was then washed in HCl to remove any carbonates.

Once these pretreatments are completed, the samples are run through the AMS, which counts the different carbon isotopes: $^{12}C$, $^{13}C$, and $^{14}C$. The amount of $^{14}C$ that is in the sample and the half-life of carbon are used to find the radiocarbon date of the sample. This date is then calibrated to find the sample's age range measured in years before present (Beta Analytic 2011, Radiocarbon Dating: An Introduction).

## Chapter 8: Results

*Test Unit in East Field over structure S6, East-1, Block 1 (Locus E-1, B-1)*

The 2010 KRAP season identified a possible Neolithic longhouse (structure S6) in the East Field during magnetic survey (Sarris and Papadopoulos 2010). Structure S6 was estimated to be 20 meters long and 8 meters wide, and was thought to have multiple rooms (Fig.3). Test unit E-1, B-1 was set up over the southwest wall of the structure over what appeared to be an opening of the southwest wall of the longhouse. Test unit E-1, B-1 was 2 meters N-S by 3 meters E-W (UTM grid coordinates were North 5204130-5204132 and East 512169-512172).

The stratigraphic sequence exposed in E-1, B-1 began with an upper and a lower plowzone layer that extended down 35 to 45 centimeters below the modern surface (see Fig. 5 for more details). Below the plowzone, there was a cultural layer that was about 15 centimeters thick. This layer included burned daub, small sherds and burned bone fragments. Structure S6 was only exposed in one-third of the unit (the northeast portion, see Fig. 6 for more details). The structure floor layer below the cultural layer was also about 15 centimeters thick, but denser than the overlying layer of daub, artifacts, and bone. The floor layer was flecked with daub and charcoal. A line of three large circular postholes, Features 1, 2, and 3, each 30 to 40 cm in diameter and ca. 40 cm deep, cut through the southwestern edge of the floor of structure S6 (see Fig. 7 for more details). The postholes had been re-excavated and the wood posts were removed when structure S6 was abandoned. There also were rodent disturbances after the posts were removed. Within the E-1, B-1 test unit, in the cultural layer that covered the floor, there was a large scatter of burned daub, a single flaked stone, a burned grinding stone, and some large ceramic body sherds. A diagnostic sherd with a finger-impressed lug, typical for the later phase of the later Middle Neolithic and the Late Neolithic, was also found on top of this floor layer.

Below the floor and the outside surface level (which was 10 to 20 centimeters thick and located southwest of the row of postholes) was a lower gray layer that was 15 to 20 centimeters thick. Sterile subsoil was encountered between 95 and 100 centimeters below the modern surface.

What was striking about E-1, B-1 was that there were only a few artifacts, bone, and charcoal fragments in the floor layer and the overlying cultural layer, and in the levels located outside of structure S6. In effect, only three radiocarbon samples were taken from this test unit (see Fig. 8 for more details). The first radiocarbon sample (#1) was a large piece of burned, but soft and weathered, daub. Sample #1 came from the daub concentration in the cultural layer above the floor of structure S6. The second radiocarbon sample (#5) included bulk sherds from the floor layer. The final radiocarbon sample from E-1, B-1 was charcoal (sample #15) that also came from the floor.

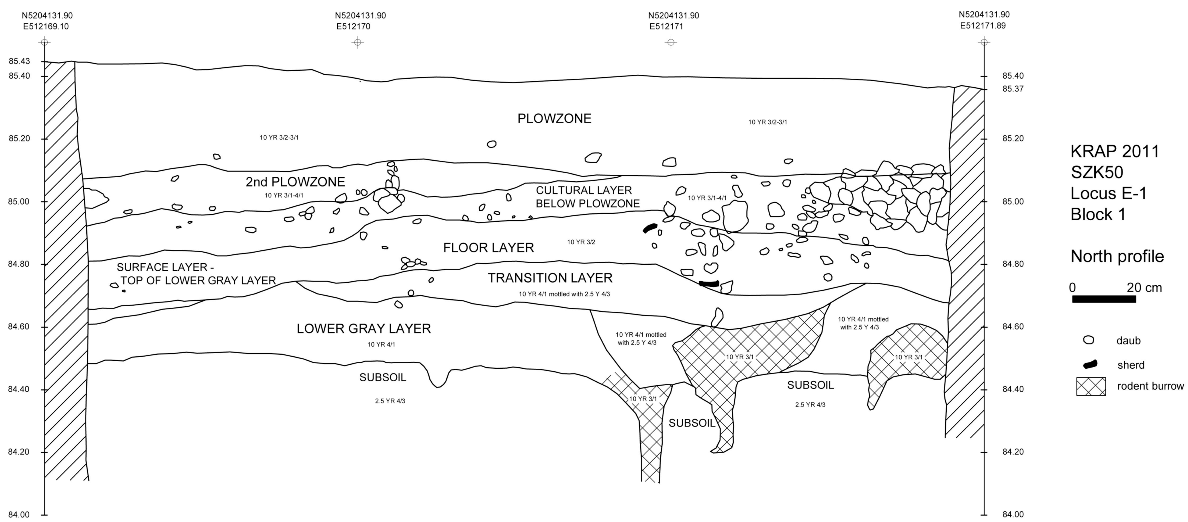



**Figure 5**: Northern profile of test unit E-1, B-1 along southwest wall of structure S6 in the East Field at SzK 50. Note daub concentration in the cultural layer below the plowzone and above the floor of structure S6 at the east (right) end of the profile. Radiocarbon sample #1 was a large piece of burned daub from this concentration. Radiocarbon sample #5 included bulk sherds from the bottom of the floor layer, and sample #15 was a small piece of charcoal on the top of the floor.

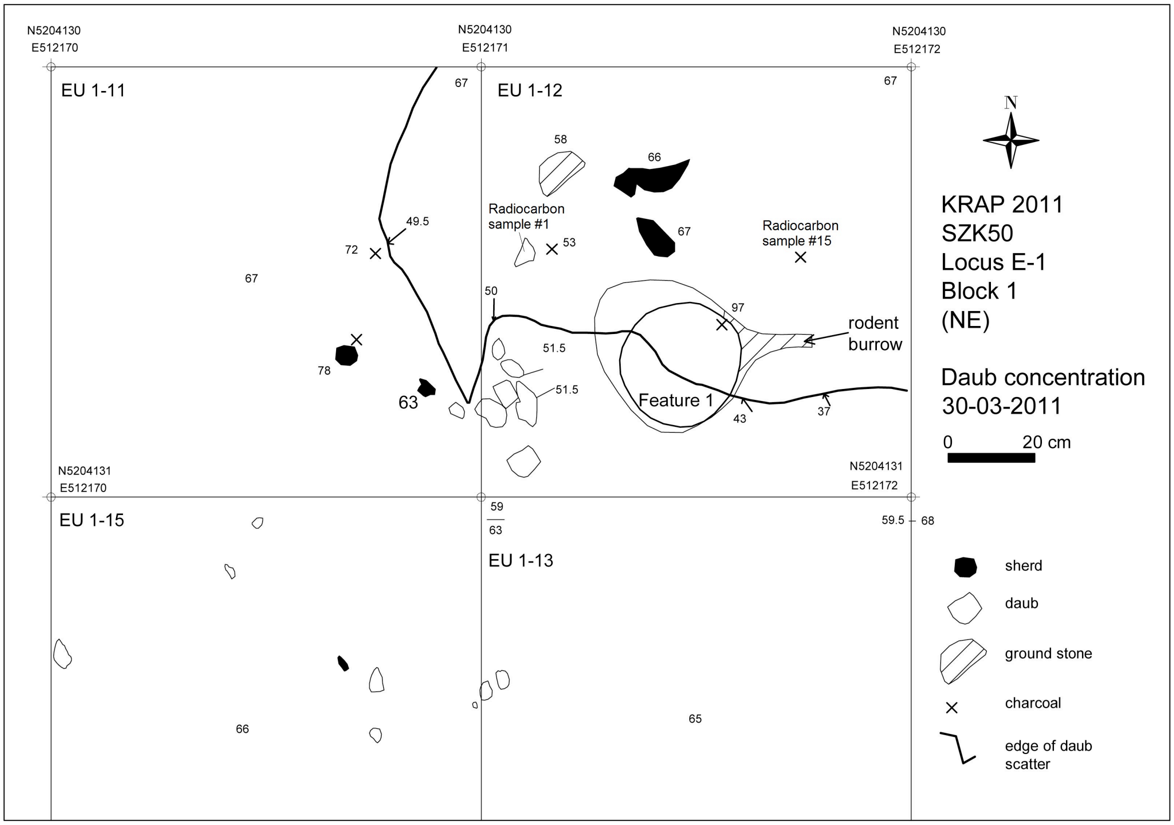



**Figure 6**: Plan map of test unit E-1, B-1, showing top of the floor layer and location of the daub concentration in the cultural layer above the floor and above the Feature 1 posthole. Small numbers are depths below the modern surface. Radiocarbon sample #1 (burned daub) was found at elevation 84.93 m ASL, 47 cm below the surface within the daub concentration. The elevation of radiocarbon sample #15 was 84.74 m ASL, 66 cm below the surface at the top of the floor layer. Radiocarbon sample #5 was on sherds from the screened sediments in the NW (upper left) quadrant on the map N5204131-4132 E512171-172, near the bottom of the floor layer (elevation 84.52-84.83 meters).

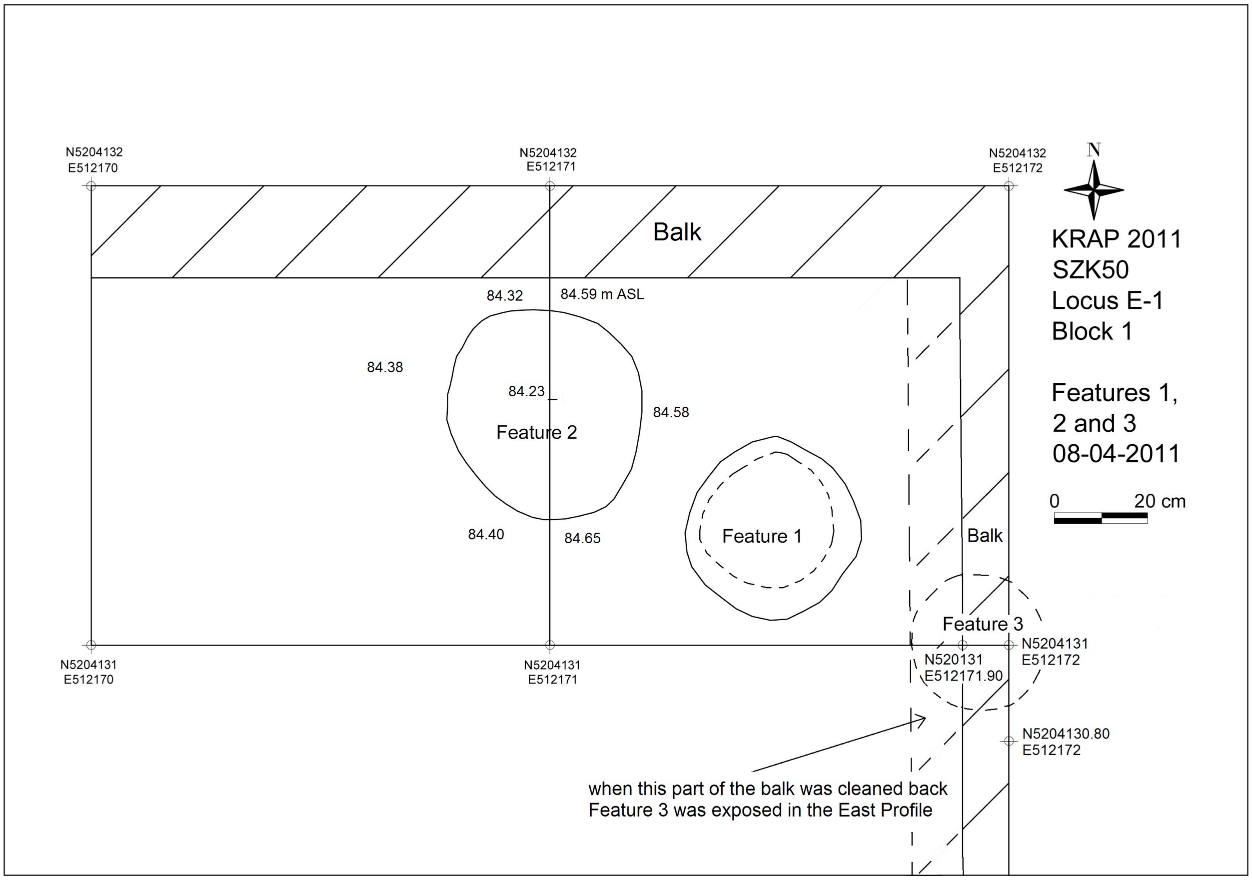



**Figure 7**: Plan map showing the postholes (Features 1, 2, and 3) in test unit E-1, B-1. Numbers are depths below the modern surface.

| Sample Number | Sample Material | EU Number | North Coord. | East Coord. | Elevation | Context |
|---|---|---|---|---|---|---|
| 1 | daub | 1 - 12 | 4131.58 | 171.18 | 84.93 m | from daub concentration in northeast portion of unit |
| 5 | sherds | 1 - 18 | 4131.00 - 4132.00 | 171.00 - 172.00 | 84.52 - 84.83 m | near the base of the floor layer of structure S-6 |
| 15 | charcoal | 1 - 16 | 4131.57 | 171.75 | 84.74 m | small charcoal fragments in the floor layer of structure S-6 |

**Figure 8**: Radiocarbon sample materials and contexts from test unit E-1, B-1. “EU number” is the designation of either a 1x1m unit of soil from one of the stratigraphic layers (e.g., cultural layer, floor, etc.) or from different-sized units of plowzone or feature fill.

*Test Unit in South Field West over structure S36, South-1, Block 1 (Locus S-1, B-1)*

Magnetometry survey during the 2010 KRAP season identified a smaller rectangular structure (S36) in the South Field West (Figures 2 and 4). During the 2011 season test excavation unit South-1, Block-1 (S-1, B-1) was laid out over the northern wall structure S36. This block was initially 3 meters N-S and 2 meters E-W (UTM grid coordinates were North 5203722-5203724 and East 511941-511943). To completely expose some intrusive features, test excavation unit S-1, B-1 was extended 1 meter north and 1.5 meters east.

The plowzone in S-1, B-1 was approximately 30 centimeters thick, and contained large amounts of daub, ceramic, lithic artifacts, and bone. Plowing might have disturbed the cultural layer below the plowzone. Two large daub concentrations were visible at the base of the plowzone in the northwest portion of the unit, and extended all the way down to the top of a possible "paleosol." The daub concentration was approximately 50 centimeters thick. An ancient surface or "walking layer" was identified outside of the structure about 45 centimeters below the modern surface. The cultural layer below the plowzone contained daub, charcoal, ceramics, human and animal bone, lithic artifacts, unworked stone, a possible ground stone tool, a loom weight, a spindle whorl, ochre, and shell. However, the floor of structure S36 was not identified in the test excavation unit. Four intrusive pits (Features 1 and 2, 3, and 4, see Fig. 9 for more details) cut into and through the cultural layer below the plowzone. Feature 1 was a rectangular feature that did not contain many daub or ceramic artifacts, and may have been a wall trench. Feature 1 is cut by Feature 2, which also appears to be a wall trench. Features 3 and 4 were contracted human burials, however neither burial contained any grave goods. There were some sherds found in the fill of Feature 4 that may date to the Early Copper Age (Tiszapolgár) period.

Feature 4 cut into a possible wall trench (Feature 6), but this older trench was disturbed by rodents and did not provide any reliable radiocarbon dates.

The larger amount of cultural material in S-1, B-1 provided more radiocarbon samples. The daub concentration in the northwest portion of the unit contained many large pieces of burned daub. Inside one of these burned daub pieces there was a sizable chunk of charcoal (radiocarbon sample #6) that could de dated. Another radiocarbon sample (#17) consisted of organic sediment in another piece of burned daub from the same context. Radiocarbon sample #7 was human bone from Feature 3, and radiocarbon sample #8 was human bone from Feature 4. Radiocarbon sample #9 was a piece of charcoal from the fill of Feature 4. Directly below the Feature 4 burial, another piece of charcoal (radiocarbon sample #10) was collected. Two radiocarbon samples were from the top of the possible "paleosol:" one piece of charcoal (sample #11), and an animal bone (sample #12). Another fragment of animal bone (radiocarbon sample #13) came from a separate EU (see Fig. 10 for more details).

**Figure 9**: Views of test excavation unit S-1, B-1 in South Field West at SzK 50. **Left**: exposure of daub concentration where radiocarbon sample #6, charcoal inside a daub fragment (5206-5050 cal. BC 1σ), was found in the original 3x2 m test unit. **Middle**: Feature 4 burial pit during excavation. Another human burial was removed from the higher pit (Feature 3) east of Feature 4 (at top of photo). Human bone (sample #8) and charcoal (sample #9) from Feature 4 produced nearly identical dates (4899-4830 cal. BC and 4893-4820 cal. BC 1σ). **Right**: Fully exposed burial in Feature 4. Radiocarbon sample #10 was found below the burial pit (5603-5530 cal. BC 1σ, on charcoal). Arrows point north, long scales are 1 meter, arrow scale is 20 centimeters long.

| Sample Number | Sample Material | EU Number | North Coord. | East Coord. | Elevation | Context |
|---|---|---|---|---|---|---|
| 6 | charcoal from inside daub | 1 - 18 | 3724.00 | 942.00 | 86.86 m | small charcoal fragments |
| 7 | human bone | 1 - 24 | 3722.00 - 3722.93 | 943.00 - 943.81 | 86.66 - 87.00 m | bottom of Feature 3 burial |
| 8 | human bone | 1 - 30 | 3723.50 | 941.46 | 86.73 m | from Feature 4 burial |
| 9 | charcoal | 1 - 31 | 3722.70 | 941.75 | 86.42 m | charcoal fragment from burial fill of Feature 4 |
| 10 | charcoal | 1 - 31 | 3722.70 | 941.80 | 86.28 m | small charcoal fragments under leg of Feature 4 burial |
| 11 | charcoal | 1 - 40 | 3723.56 | 942.70 | 86.54 m | in cultural layer above paleosol |
| 12 | animal bone | 1 - 40 | 3723.56 | 942.70 | 86.54 m | in cultural layer above paleosol |
| 13 | animal bone | 1 - 41 | 3723.00 – 3724.00 | 941.00 – 942.00 | 86.52 - 86.79 m | in cultural layer above paleosol |
| 17 | daub | 1 - 18 | 3721.37 - 3722.05 | 951.67 - 942.97 | 86.80 - 86.87 m | thick layer of predominantly burned daub |

**Figure 10**: Radiocarbon sample materials and excavated contexts from test excavation unit S-1, B-1 above structure S36 in South Field West at SzK 50.

*Radiocarbon Dating Results*

The organic artifacts selected for radiocarbon dates were sent to Beta Analytic's radiocarbon laboratory. Figures 8 and 9 describe the context from which each sample was taken. The samples were pretreated at Beta Analytic's laboratory, following the guidelines described previously. The results from these samples are listed in Figures 11 and 12, which include the sample's age in radiocarbon years before present (in BP), the 1 sigma calibrated dates (in cal. BC), and the 2 sigma calibrated dates (in cal. BC).

Most of the samples from test excavation unit S-1, B-1 do not have multiple intercepts that are chronologically distinct. The charcoal found below Feature 4 (sample #10) is dated to 5620-5480 cal. BC (2 sigma). This date is the earliest from the test excavation unit at structure S36. Sample numbers 7, 8, 9, 11, 12, and 13 produced radiocarbon dates that were not statistically different from each other at the 95% confidence level (see Fig. 13), and fall between approximately 5000 cal. BC and 4690 cal. BC (2 sigma). Sample #7 had multiple intercepts, but the dates were very close together (approximately 200 years, cal.). Sample #6 was a large piece of burned daub with charcoal inside. The charcoal was dated to 5210-4950 cal. BC (2 sigma). This date is slightly earlier than the other samples from S-1, B-1 (sample numbers 7, 8, 9, 11, 12, and 13), although there is a small overlap between these dates (260 years, cal.). Sample #17 was another piece of burned daub from S-1, B-1. The organic material in this sample was dated to be from 2460-2200 cal. BC (2 sigma). Similar to the daub radiocarbon date from E-1, B-1 (sample #1), this date is much younger than the Late Neolithic period.

From the three radiocarbon samples taken from test excavation unit E-1, B-1 at structure S6, only one gave a reliable date of this structure. Sample #1 was a sample of daub, and the radiocarbon date had multiple intercepts, and each were only a few hundred years BC (calibrated). These dates are much younger than the Late Neolithic period. The sherds (sample #5) also had multiple intercepts, which were around 6000 cal. BC (2 sigma), which would fall within the Early Neolithic period. Data collected from the charcoal fragments (sample #15) from the floor of structure S6 did not have multiple intercepts, and gave a more accurate date for the structure when compared to samples #1 and #5. The calibrated radiocarbon date from sample #15 appears to fall in the range of the Late Neolithic of this region (see Figure 10 for more detailed descriptions of these data). Figure 12 shows sample #15 with other samples from S-1, B-1. A t-test showed that there was a statistical difference between sample #15 and sample numbers 7, 8, 9, 11, 12, and 13.

The data from sample #17 can be compared to sample #6 because they were taken from the same context. The date from the charcoal sample (sample #6) falls into line with the other reliable dates from charcoal (samples #10 and #9) and bone (samples #7 and #8). The radiocarbon date from the daub (sample #17) does not give a date close to the date from the charcoal (sample #6).

| Sample Number | Sample Material | EU Number | Conventional $^{14}C$ Age | 2 Sigma Calib. | 1 Sigma Calib. |
|---|---|---|---|---|---|
| 1 | daub | 1 - 12 | 2300± 30 BP | 400 - 360, 270 - 260 cal. BC | 400 - 380 cal. BC |
| 5 | sherds | 1 - 18 | 7350± 40 BP | 6340 - 6310, 6260 - 6090 cal. BC | 6340 - 6210 cal. BC |
| 15 | charcoal | 1 - 16 | 5790± 40 BP | 4720 - 4540 cal. BC | 4710 - 4590 cal. BC |

**Figure 11**: AMS Radiocarbon dates on samples from test excavation unit E-1, B-1 along southwest wall of structure S6 in the East Field at Szk 50.

| Sample Number | Sample Material | EU Number | Conventional $^{14}C$ Age | 2 Sigma Calib. | 1 Sigma Calib. |
|---|---|---|---|---|---|
| 6 | charcoal from inside burned daub | 1 - 18 | 6130± 40 BP | 5210 - 4950 cal. BC | 5200 - 5170, 5070 - 5000 cal. BC |
| 7 | human bone | 1 - 24 | 5970± 40 BP | 4950 - 4770, 4750 - 4740, 4730 cal. BC | 4910 - 4860, 4860 - 4790 cal. BC |
| 8 | human bone | 1 - 30 | 5950± 40 BP | 4940 - 4720 cal. BC | 4890, 4880 - 4870, 4850 - 4790 cal. BC |
| 9 | charcoal | 1 - 31 | 5940± 40 BP | 4930 - 4720 cal. BC | 4840 - 4780 cal. BC |
| 10 | charcoal | 1 - 31 | 6590± 40 BP | 5620 - 5480 cal. BC | 5610 - 5590, 5560 - 5480 cal. BC |
| 11 | charcoal | 1 - 40 | 6000± 40 BP | 5000 - 4790 cal. BC | 4940 - 4840 cal. BC |
| 12 | animal bone | 1 - 40 | 5890± 40 BP | 4840 - 4690 cal. BC | 4790 - 4720 cal. BC |
| 13 | animal bone | 1 - 41 | 6000± 40 BP | 5000 - 4790 cal. BC | 4940 - 4840 cal. BC |
| 17 | burned daub | 1 - 18 | 3840± 30 BP | 2460 - 2200 cal. BC | 2400 - 2380, 2340 - 2280, 2250 - 2230, 2220 - 2210 cal. BC |

**Figure 12**: AMS Radiocarbon dates on samples from test excavation unit S-1, B-1 along north wall of structure S36 in the South Field West at Szk 50.

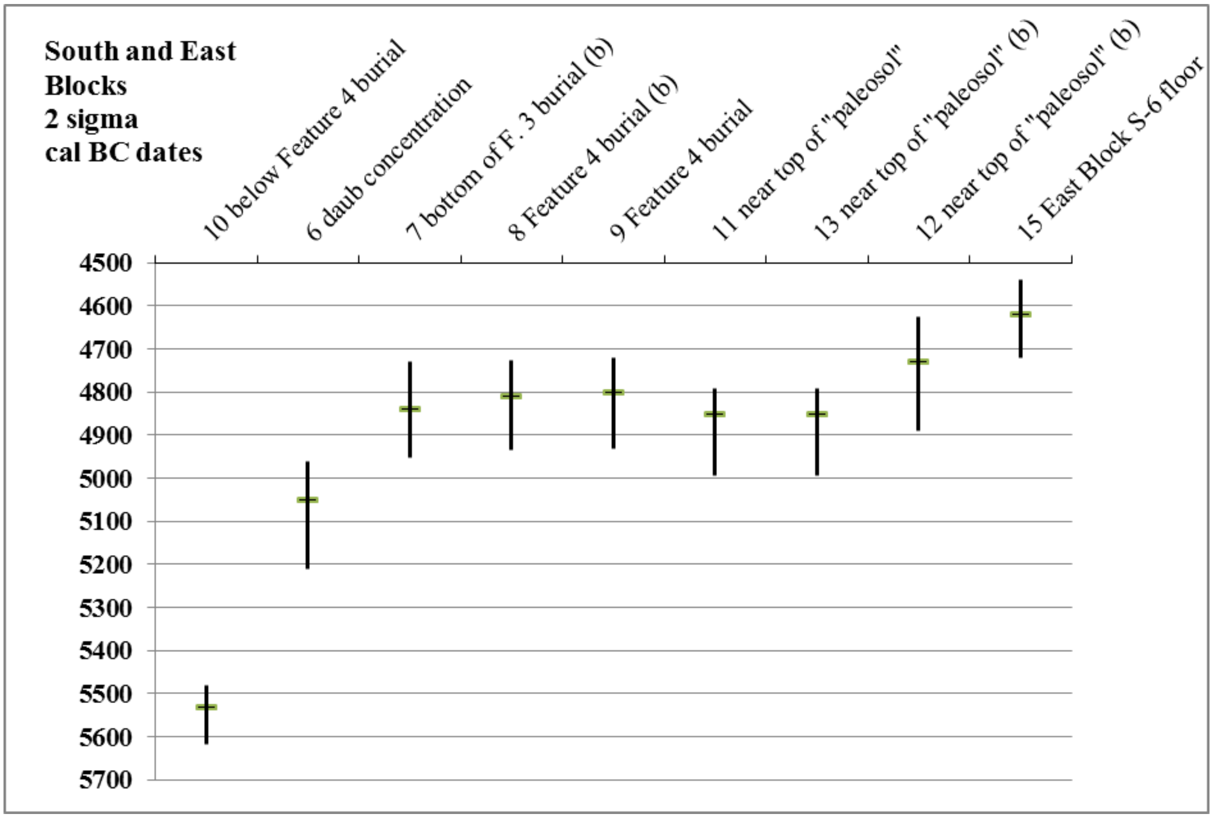



**Figure 13**. Calibrated $^{14}C$ dates from S-1, B-1 and E-1, B-1 test excavation units at SzK 50. Using Calib Rev. 6.1 on Beta dates, 2 sigma CAL BC. (b) marks bone samples, unmarked are charcoal samples. Sample numbers and contexts are listed at top. The sample on the right is from the floor of structure S6 in E-1, B-1, all others are from S-1, B-1 and structure S36. Cross mark is the intercept of the calibration curve, or the youngest value if there are multiple intercepts. T-test result on six dates (sample numbers 7, 8, 9, 11, 13, 12) revealed no significant difference at the 95% level (T=5.427, Xi2=11.1, 0.05, 5 df). When #15 is added to those six, there is a significant difference at the 95% level (T=20.6, Xi2=12.6, 0.05, 6 df). Summed probabilities for the six dates are 4964-4715 cal. BC (99% under curve, 2σ).

## Chapter 9: Interpretation and Conclusion

Of the three radiocarbon dates on daub samples, only one yielded a radiocarbon date that fell within the chronological sequence of other associated dates. This date, from sample #6 from S-1, B-1, and structure S36 was on a piece of charcoal found inside of the burned daub fragment. This was not an example of a successful date extracted from burned daub. Daub samples #1 and #17 (from E-1, B-1 and S-1, B-1, respectively) both yielded radiocarbon dates that were several thousand years younger than other radiocarbon dates from structures S6 and S36.

Sample #17 provides a compelling example for the inaccuracy of the daub radiocarbon date, because this sample was taken from an excavation unit that also had a sample of charcoal (sample #6), from inside another piece of daub from the same context. Both samples should have been dated to the same time interval. Instead of similar radiocarbon dates, the samples differed by approximately 2,500 years.

The young dates from the daub could be from contamination after they had been deposited. Daub is subject to diagenic changes, and its porous quality may facilitate contamination. It is possible that groundwater introduced humic acids (Cohen-Ofri et al. 2006) and molecules that contain carbon into the daub pieces. This new source of carbon could cause the radiocarbon date to appear more recent than the "true age" of the daub and the burned wattle-and-daub structure they came from.

Radiocarbon dates and artifact analysis have shed light onto the chronology of structures S36 and S6 excavated in S-1, B-1 and E-1, B-1. It seems that the structure S36 (S-1, B-1) was older and occupied for a longer time than the S6 longhouse (E-1, B-1). This was initially suggested by the magnetometry data gathered from the 2010 KRAP season (Fig. 4), which shows many magnetic anomalies probably due to human activity in the South Field West where structure S36 was located. The magnetometry data from the East Field does not show nearly as many anomalies: structure S6 is fairly isolated on the Figure 2 maps. The number of intrusive features in test excavation unit S-1, B-1 (Features 1 and 2, each which appeared to be wall trenches, as well as Features 3 and 4 that were human burials) also reinforces the argument that occupation of the South Field West area extended over several centuries. The excavation in E-1, B-1 confirmed the magnetometry data, in that there were no intrusive features in the East Field due to a later, and especially shorter, occupation of the area. Structure S6 in E-1, B-1 seems to have only one period of occupation.

This one period of occupation was able to be dated by charcoal in the floor of structure S6 (sample #15), and was measured to be between 4720-4540 cal. BC (2 sigma). The date from the burned sherds (sample #5) was at least 1,000 years (cal. BC) older than the charcoal date (sample #15). There are at least two possible explanations for the difference between the dates. The ceramic could be from the same time period as sample #15 estimates, but made from clay that had older organic material incorporated into it. This would explain the much older date. Another explanation could be that the estimated date of the sherds is accurate, but the sherds were “curated” by the Late Neolithic inhanitants of structure S6 and date to older Early Neolithic occupations near SzK 50. Topographic analysis shows that the S6 longhouse is at a low elevation (Figs. 2 and 14), and could have been subject to episodes of flooding. In addition to being occupied for a shorter period, the S6 longhouse at E-1, B-1 appears to have been occupied at a later date than the structure and burial features in S-1, B-1.

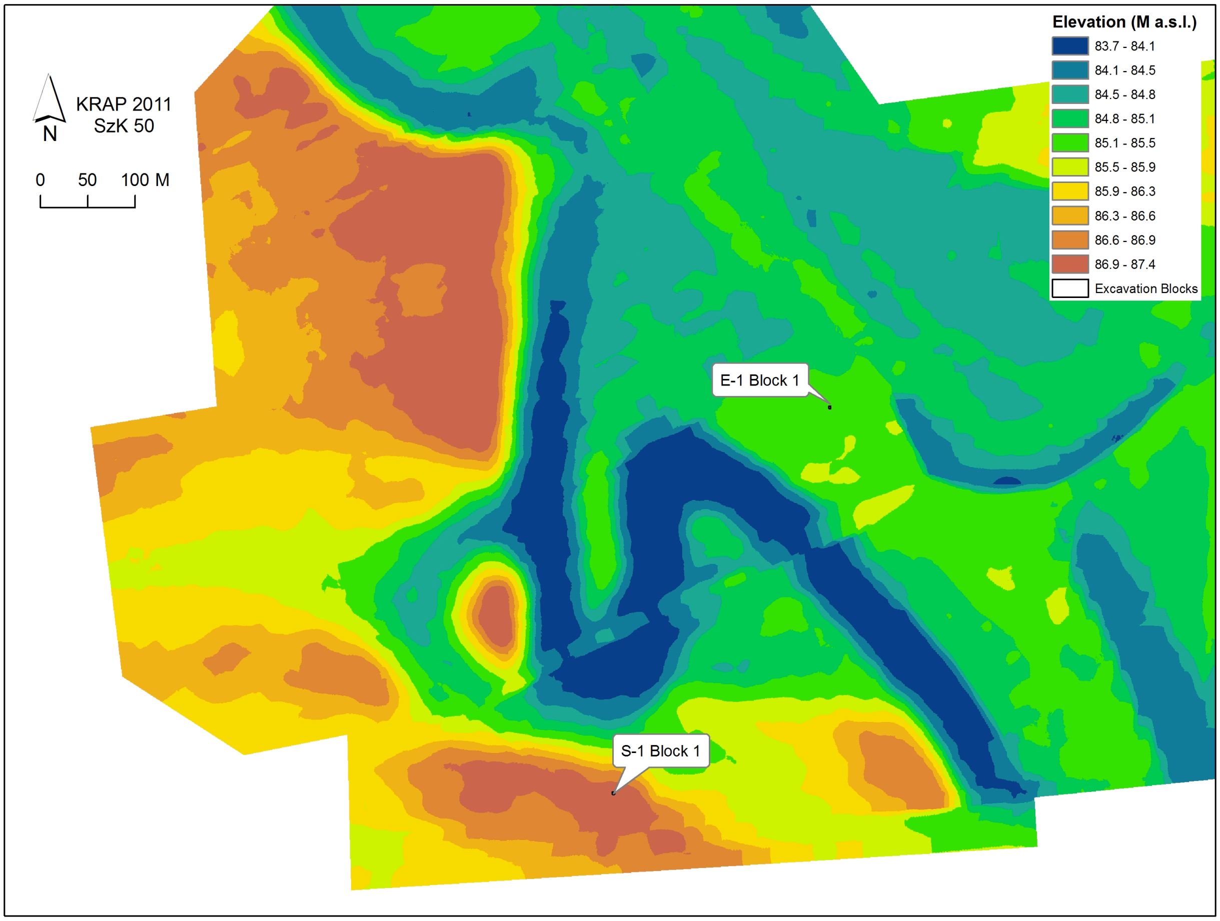



**Figure 14**: Topography of SzK 50 indicating higher elevation of the S-1, B-1 test excavation unit compared to the E-1, B-1 block.

The greater number of artifacts and datable organic material from test unit S-1, B-1 allowed for the occupation of the denser South Field West area to be defined. The radiocarbon dates from S-1, B-1 encompass and interval of 930 years at 2 sigma: 5620 cal. BC (sample #10) to 4690 cal. BC (sample #12). However, samples #9 and #10 were from the same excavation unit, but had measured years that were several hundred years apart (4930-4720 cal. BC, 2 sigma and 5620-5480 cal. BC, 2 sigma, respectively). This could be because the burial fill layer that contained sample #9 was younger than the layer that contained sample #10, or that the wood from charcoal sample #10 was older than the wood from charcoal sample #9.

The purpose of this study was to determine if radiocarbon dates taken from burned daub would yield accurate date of ancient burned wattle-and-daub structures. Based on the limited samples in this study, radiocarbon dates from the daub do not provide dates that can be attributed to the life of the structures. The one date from daub that provided an accurate radiocarbon date was actually from a piece of charcoal inside. In this instance, it would be possible to obtain a plausible date, although technically the source of this date is from a charcoal sample, and not daub. Other organic samples taken from blocks S-1, B-1 and E-1, B-1 gave more reliable radiocarbon dates that are associated with the structures from each block. A chronology of the structures was then established, indicating that structure S36 partially exposed in test excavation unit S-1, B-1 was older than the part of the S6 longhouse found in test unit E-1, B-1, and that the South Field West area of SzK 50 was occupied for a longer time than the one-time occupation of structure S6 in the East Field. The structure S6 and S36 were not very chronologically different, but their relative sizes and durations of occupation were not similar. This chronology may support the current theory (Parkinson et al. 2010) that the transition from highly nucleated settlements to smaller, dispersed settlements was a gradual process. Future research should focus on dating organic material that is already known to provide accurate radiocarbon dates.

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